



ORIGINAL ARTICLE

Computed tomography benefits and cost in hemodynamically stable patients with blunt abdominal trauma at an Egyptian University Hospital

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ABSTRACT

Background: Trauma is a significant cause of mortality, especially among individuals aged between 15 and 44 years, with a substantial burden falling on economically active populations. Low- and middle-income countries (LMICs) bear the burden of trauma-related deaths, accounting for over 90 % globally. In Egypt, trauma rates are increasing, primarily due to road traffic crashes (RTC), affecting males disproportionately. Blunt abdominal trauma, often caused by RTC, can lead to missed intra-abdominal injuries (IAIs) due to atypical symptoms. Computed Tomography (CT) offers high sensitivity and specificity in detecting IAIs, but concerns about cost and radiation exposure exist.

Methodology: This study investigates the roles of Focused Assessment with Sonography for Trauma (FAST) and CT in managing blunt abdominal trauma. A retrospective cohort study was conducted on hemodynamically stable patients. Data included patient demographics, trauma details, healthcare decisions, costs, and outcomes.

Results: Computed tomography significantly reduced unnecessary laparotomies (12.3% vs. 24.8 %, $p = 0.001$), shortened hospital stays (4.83 ± 0.71 days vs. 6.15 ± 1.28 days, $p = 0.005$), and reduced ICU admissions (8 vs. 32, $p = 0.023$) compared to FAST alone. Overall costs were lower in the CT & FAST Group (\$2055.95 vs. \$3488.7, $p = 0.0001$), with no significant difference in missed IAIs.

Conclusion: This study highlights the limitations of relying solely on FAST for IAIs and underscores the value of CT in guiding healthcare decisions. Incorporating CT led to reduced negative laparotomies, shorter hospital stays, and fewer ICU admissions. While CT incurs initial costs, its long-term benefits outweigh expenditures, particularly in LMICs. This study provides insights into optimizing diagnostic approaches for blunt abdominal trauma in low-resource settings.

African relevance

- This study was performed in Egypt, questioning the value of the use of CT scans in low- and middle-income countries.
- This study provides evidence around best utilization of scarce resources and cost analysis which is relevant to many African settings facing prioritising limited resources such as access to CT scans.

- Trauma in Egypt, as in the rest of Africa represents a significant burden mandating the sound choice of management pathways.

Introduction

Trauma is a leading cause of mortality, especially in economically productive populations, with nearly half of injury-related deaths occurring in individuals aged 15 to 44 years [1]. Low- and

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middle-income countries (LMIC) bear the brunt of these injury-related deaths, accounting for over 90 % of such fatalities worldwide [2]. In Egypt, the incidence of trauma is on the rise, primarily attributed to road traffic crashes (RTC), with males being disproportionately affected. Studies in Egypt found that males comprised 78–88 % of abdominal trauma cases [3–6].

Blunt abdominal trauma is often caused by RTC. Unlike head or chest injuries, which have clear clinical signs, abdominal injuries can have normal or less obvious symptoms, which could cause intra-abdominal injuries (IAIs) to be missed [7]. Delayed diagnosis and missed IAIs are linked to poor outcomes [8]. Computed Tomography (CT) has achieved a high sensitivity of approximately 96.7 %, a specificity of 96.6 %, and a negative predictive value (NPV) of 99.7 % for detecting IAIs, thus reducing the risk of missed IAIs [9].

The use of CT as a diagnostic tool has its challenges. The procedure is costly, necessitates patient transportation from the Emergency Room to the CT suite, involves exposure to radiation, and others. As a result, various alternatives to CT have been proposed, including scoring systems based on clinical, laboratory, and radiographic criteria as well as prolonged observation periods of 12 to 24 h for clinically stable patients with blunt abdominal trauma [4,10].

While relying on CT in LMIC might initially appear financially burdensome, it is crucial to consider the long-term implications. The costs associated with readmissions, operative procedures, and mortality are significantly higher in low-resource areas, making the adoption of CT a potentially cost-effective approach [11]. This study aims to investigate the role of both Focused Assessment with Sonography for Trauma (FAST) and CT in patients with blunt abdominal trauma, assessing the rates of missed IAIs, negative laparotomies, the necessity for more costly interventions, and overall costs compared to utilizing FAST alone. By shedding light on these factors, we seek to provide valuable insights into optimizing the diagnostic approach for hemodynamically stable patients with blunt abdominal trauma at Ain Shams University Surgery Hospital.

Methods

This retrospective cohort study utilized data collected between January 2018 and December 2019 from the records of El Demerdash Hospital, the surgical hospital within Ain Shams University Hospitals, located in Cairo, Egypt. The study aimed to include adult patients who had presented with blunt abdominal trauma and were hemodynamically stable during their hospitalization. The study population was selected based on available medical records meeting the inclusion and exclusion criteria.

Inclusion criteria encompassed individuals aged ≥ 18 years, who were classified as either class I or class II according to the Advanced Trauma Life Support (ATLS) classification for hemorrhagic shock. Exclusion criteria comprised cases with hemodynamic instability (class III or IV), pregnancy, impaired renal function, hypersensitivity to contrast material, and concurrent pelvic or femur fractures.

Patient data were extracted from the hospital's medical records, by some of the authors and a team of house officers, using a preprinted form. The dataset included demographic information, details of the traumatic event, reasons for abdominal exploration, outcomes of laparotomy procedures, occurrences of missed intra-abdominal injuries (IAIs), length of hospital stay, admissions to the intensive care unit (ICU), associated costs of diagnostic procedures such as Focused Abdominal Sonography for Trauma (FAST) and contrast-enhanced abdominopelvic Computed Tomography (CT), interventions performed, and healthcare decisions made during the hospitalization period.

The decision to perform contrast-enhanced CT had been made at the discretion of the attending physicians during the patients' clinical management, but the CT request should be approved by the General Surgery consultant on duty. The CT scan findings suggestive of IAIs were

identified through a review of radiology reports. These findings included visualizations of abnormalities in the liver, spleen, adrenal gland, gallbladder, kidney, and pancreas, as well as indicators like intraperitoneal fluid, bowel wall edema, mesenteric edema, mesenteric streaking, mesenteric hematoma, pneumoperitoneum, or contrast extravasation. The FAST scans and CT interpretation and reporting were done by experienced radiologists who had at least 3 years of training.

The cost analysis constitutes a pivotal and comprehensive component of this study, serving to thoroughly evaluate the financial implications intrinsic to the diagnostic and management strategies under study. In El Demerdash Hospital the majority of hospital services, including imaging, were extended either free of charge or at substantially reduced rates. To navigate this distinct scenario and arrive at precise cost estimations, the prevailing rates associated with services were meticulously extracted from the official price list of Ain Shams Specialized Hospital (ASUSH). ASUSH, being a prominent constituent of the Ain Shams University Hospitals network, provided the reference framework for deriving these cost calculations. The outcome of this calculation was translated into monetary terms, embodying the expenditures that would be associated with the services offered.

The actual price list of ASUSH, applicable for the corresponding years of the study, was meticulously employed. Notably, certain cost calculations were straightforward, such as determining the expenses associated with hospital stays or ICU stays. The price of a standard double room or ICU bed stay was multiplied by the number of nights spent, thereby yielding a representative cost for these accommodations. Additionally, costs related to blood transfusions and blood products were directly calculated by multiplying the cost of each bag of blood or blood product by the number of bags actually administered to patients. The financial evaluation of interventions was nuanced by the structure of package offerings and investigations. Certain interventions were conveniently presented as packages, while diagnostic investigations followed a distinct costing structure.

A significant dimension was the estimation of costs associated with medications and consumables. This involved calculating the average expenditure for medications and consumables incurred by patients undergoing conservative management or interventions at ASUSH. The next step encompassed dividing these averaged costs by the total hospital stay days for both ward and ICU stays. The resulting average cost was then multiplied by the actual hospital stay duration for individual patients, yielding a robust approximation.

Overhead or service fees, a customary practice within the ASUSH financial framework, were accounted for. A standardized rate of 12 % for overhead/service fees was applied, mirroring the structure practiced within ASUSH. This meticulous and detailed approach ensured that the cost analysis incorporated not only overt expenses but also factors that contribute to the comprehensive financial landscape associated with trauma management.

This pragmatic approach ensured that the financial ramifications were accurately captured and thereby bolstered the fidelity and applicability of the cost analysis within the real-world context.

The collected data underwent review, coding, and entry into IBM SPSS version 26.0 for comprehensive analysis. Categorical variables were expressed as percentages and numbers, and between-group comparisons were conducted using the Chi-square test. Quantitative variables were summarized using means, standard deviations, and ranges, with comparisons between groups executed using the Independent *t*-test. A 95 % confidence interval was employed, with a 5 % margin of error defining statistical significance, indicated by *p*-values < 0.05 .

This study received ethical approval from both the Research Ethics Committee (REC) within the General Surgery Department of Ain Shams University (IRB: 00006379) and the Institutional Review Board (IRB) at the University of Maryland, Baltimore.

Results

During the designated two-year study period, a total of 352 patients were enrolled. Among these, 106 patients underwent both Abdominal CT and FAST (Group A), while 246 patients underwent only FAST (Group B) (Table 1).

Health care decisions and length of hospital stay, including ICU admission

The utilization of contrast-enhanced CT significantly influenced healthcare decisions, resulting in a substantial reduction in laparotomies for patients in the CT and FAST Group (12.3 %) compared to the FAST Group (24.8 %) ($p = 0.001$). The cause of abdominal exploration did not exhibit a noteworthy difference between the groups. Patients who underwent abdominal CT experienced a significantly shorter hospital stay (CT: 4.830.71 days vs. no CT: 6.151.28 days, $p = 0.002$) and a decreased occurrence of ICU admissions (CT: 8 vs. no CT: 32, $p = 0.023$) when compared to the FAST Group (Table 2).

The combination of CT scans and FAST notably contributed to a reduced rate of negative laparotomies compared to the FAST Group (CT & FAST Group: 12.3 %, FAST Group: 24.8 %, $p = 0.026$), leading to diminished morbidity, costs, and mortality risk associated with operative interventions.

Cost analysis

The cost analysis revealed that the average cost, including intervention expenses (laparotomy or radiological intervention), radiographic modalities (CT and FAST), as well as hospital and ICU stays, was significantly lower in the CT & FAST Group (\$2055.95) compared to the FAST Group (\$3488.7) ($p = 0.0001$). However, no significant difference was detected between the two groups concerning missed IAIs (Table 3).

It is important to note that the figures presented above may vary from one patient to another. However, given the primary focus of this study, it is worth mentioning that the cost of a CT scan of the abdomen and pelvis ranges from \$90 to \$160, depending on the protocol used and the amount of dye required. In contrast, a FAST scan may cost only \$15 to \$25.

Overall cost includes the expenses related to interventions (laparotomy or radiological intervention), radiographic modalities (CT and FAST), as well as hospital and ICU stays.

Discussion

Trauma management presents a substantial challenge, especially in LMICs. The rising prevalence of road traffic crashes in LMICs, coupled with inadequate infrastructure, underdeveloped emergency response systems, and limited healthcare facilities, strains healthcare resources considerably [10,11]. Our study explores a critical aspect of this challenge by investigating the financial implications of managing hemodynamically stable patients with blunt abdominal trauma.

Table 1
Demographic data of included participants.

	CT & FAST Group (N = 106)	FAST Group (N = 246)	p-value
Age (years), mean ±SD	34.8 ± 11.3	35.3 ± 10.2	0.475
Gender (%)			
- Male	68 (64.2 %)	190 (77.2 %)	0.060
- Female	38 (35.8 %)	56 (22.8 %)	
Mode of Trauma (%)			
- Road Traffic Crash	61 (57.5 %)	140 (57.0 %)	0.280
- Falls	32 (30.2 %)	86 (35.0 %)	
- Assaults	6 (5.7 %)	12 (4.9 %)	
- Others	7 (6.6 %)	8 (3.3 %)	

Table 2
Health care decisions and length of hospital stay, including ICU admission.

	CT & FAST Group (N = 106)	FAST Group (N = 246)	p-value
Health Care Decision			
- Conservative Management	68 (64.2 %)	157 (63.8 %)	0.001*
- Interventional Radiology	13 (12.3 %)	0 (0.0 %)	
- Exploratory Laparotomy	25 (23.6 %)	89 (36.2 %)	
Cause of Abdominal Exploration			
- Visceral Injury	4 (23.5 %)	20 (13.0 %)	0.134
- Splenic Rupture	7 (41.2 %)	39 (25.2 %)	
- Internal Bleeding	4 (23.5 %)	63 (40.9 %)	
- Presence of Haemoperitoneum	2 (11.8 %)	6 (3.9 %)	
Hospital Stay (days), Mean ±SD	4.83±0.7	6.15±1.3	0.005*
ICU Admission			
- No	24 (75 %)	81 (33 %)	0.023
- Yes	8 (25 %)	165 (67 %)	
Days in ICU, Mean±SD	1.6 ± 0.5	2.0 ± 0.9	0.211

* Statistically significant.

Table 3
Cost analysis.

	CT & FAST Group (N = 106)	FAST Group (N = 246)	p-value
Cost of Intervention	\$1862.90±573.14	\$3456.52±697.82	0.0001*
Overall Cost, Mean ±SD	\$2055.9 ± 584	\$3488±694.7	0.0001*

* Statistically significant.

The average age of our patients was 34.17 years, with a standard deviation of 11.34, aligning with patterns often observed in trauma studies in high income countries[4,12]. Moreover, 64.2 % of the patients were males, a reflection of the documented vulnerability of physically active males to trauma in LMIC [6,13]. Road traffic crashes (RTC) constituted the leading cause of trauma in our study, accounting for 57.5 % of cases, in line with research from other LMICs, where RTCs are a significant contributor to trauma incidents, followed by falls at 30.2 %, assaults at 5.7 %, and other causes at 6.6 % [14].

Our study highlights the limitations of relying solely on Focused Abdominal Sonography for Trauma (FAST) in identifying intra-abdominal injuries (IAIs). Despite its utility, FAST’s consistently low sensitivity can lead to missed IAIs. This is consistent with previous studies where negative FAST results were linked to subsequent CT-detected injuries [15,16]. The introduction of contrast-enhanced CT scans significantly impacted healthcare decision-making by reducing unnecessary interventions and optimizing resource use [17–19]. The CT & FAST Group experienced a 50 % reduction in unnecessary laparotomies compared to the FAST Group, resulting in minimized patient discomfort, complications, and substantial cost savings. The non-operative management strategy, while potentially leading to longer hospital stays, is associated with decreased blood transfusion requirements and comparable mortality rates [4]. The cause of exploration in both groups showed an interesting pattern, in the CT & FAST Group the most common cause of exploration was due to splenic injuries, while in the FAST Group, most of the cases were explored due to the presence of abdominal collection, but there was no statistically significant difference between the two groups.

Our study demonstrated a significant decline in ICU admissions (75 % reduction) in the CT & FAST Group compared to the FAST Group, indicating the potential of CT scans to optimize patient care and resource utilization. Patients undergoing abdominal CT also experienced notably shorter hospital stays (21 % reduction) compared to the

FAST Group, emphasizing the efficiency of CT scans in healthcare management.

Expressing all costs in US dollars (USD) facilitates international comparisons and mitigates perception differences due to inflation or changes in currency value. While the introduction of CT scans invites additional costs, their long-term benefits, including preventing missed IAIs, and potential mortalities, outweigh these initial expenditures. A UK study emphasized the significant contribution of hospital stays to the overall financial burden of blunt trauma [20]. However, cost evaluation in LMIC remains variable across studies, necessitating tailored approaches to address financial considerations [10].

It is essential to note the limitations of our study. Being a retrospective study, it is inherently more prone to selection bias [21], as the CT scans were certainly ordered by the consultants to address specific questions raised in each case, and it was usually ordered after receiving the FAST scan results. Other limitations include the absence of data on indirect costs, such as sick leaves, reduced productivity, and follow-up expenses related to blunt trauma. Furthermore, the lack of long-term follow-up data, including re-admissions, postoperative complications, and referrals, hinders the comprehensive interpretation of our findings.

Conclusion

In conclusion, our study illuminates the delicate balance between the initial costs and long-term benefits associated with the use of CT scans in managing hemodynamically stable patients with blunt abdominal trauma. Despite the upfront expenses, CT scans play a critical role in preventing missed IAIs, reducing hospital stays, and optimizing overall patient care and resource allocation. Further studies and detailed cost-effectiveness analyses are imperative to inform evidence-based decisions and enhance trauma management strategies in resource-constrained settings.

Dissemination of results

Results from this study research were shared with staff members of the General Surgery Department, Ain-Shams University.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT in order to enhance style and correct typing errors. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

Authors' contribution

Authors contributed as follows to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: MAH contributed 55 %; MAA 25 %; MN, ME, JMH, and ME contributed 5 % each. All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interest

This research was funded throughout all its steps by the Fogarty Institute, USA. The authors declared no other conflicts of interest.

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